

Climate-responsive urban and building design

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Panel of experts New Fayoum City, Egypt, 25-27 September 2012

## CLIMATE-RESPONSIVE URBAN AND BUILDING DESIGN

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Environmental Consultant  
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Panel of experts New Fayoum City, Egypt, 25-27 September 2012

## Urban Design Criteria in hot-dry climate areas

- Urban grid layout allowing northern wind penetration in streets and public spaces for summer outdoor comfort
- Barriers (walls, vegetation) protecting buildings from southern sand-bearing wind
- Multi-storey residential buildings laid along the N-S axis to allow for the apartments being naturally ventilated and cooled by airflow crossing the rooms from a inlet north-facing *malkaf* to outlet south-open solar chimneys; both elements are serving a single apartment for each storey of a vertical row by organ pipes-like ducts, distributing cold room-inlet air through ceiling and exhausting warm room-outlet air through vents on the bottom of southward walls.
- Building rows fairly closed to each other to project morning and afternoon shadows on, respectively, eastward and westward facades; alternatively, trees rows can be planted between buildings.

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## Urban Design Criteria in hot-dry climate areas

- Trees and vegetation foreseen in a quantity higher than a threshold related to their potential for reducing heat island effect as well as absorbing carbon emissions.
- Pavement and external walls cladding materials characterised by low *albedo* (coefficient of short-wave thermal radiation) and low *emissivity* (coefficient of long-wave thermal radiation) to avoid outdoor overheating conditions.
- Outdoor elements and furniture laid out and designed to function as shading and warm wind barriers.
- Sprayed water, ponds, and fountains provided as evaporative cooling systems for outdoor spaces.

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## Building Design Criteria in hot-climate areas

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### ADAPTIVE COMFORT: A FIELD STUDY

Buildings with Centralized HVAC

Indoor Comfort Temperature, Top (°C)

Outdoor Temperature Index, ET\* (°C)

Legend: Observed: Field-based adaptive model, Predicted: Lab-based PMV model

Study by a LBNB' team, Berkeley, 2003: comparison between indoor comfort conditions perceived and calculated, in sample buildings with centralised HVAC

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### ADAPTIVE COMFORT: A FIELD STUDY

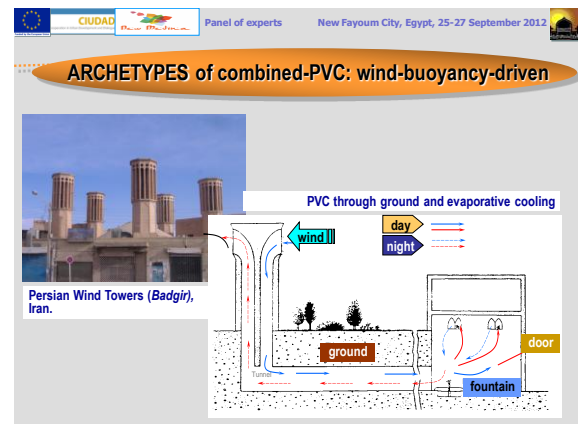
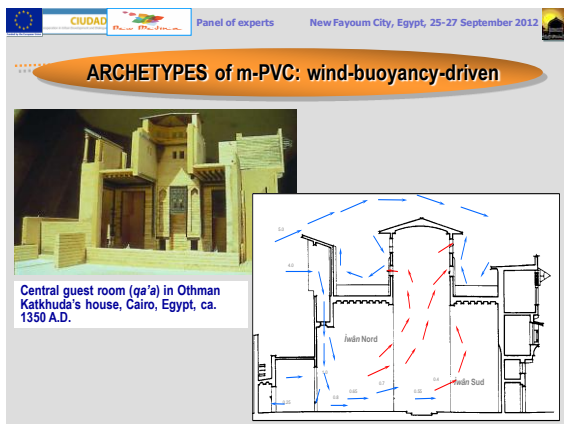
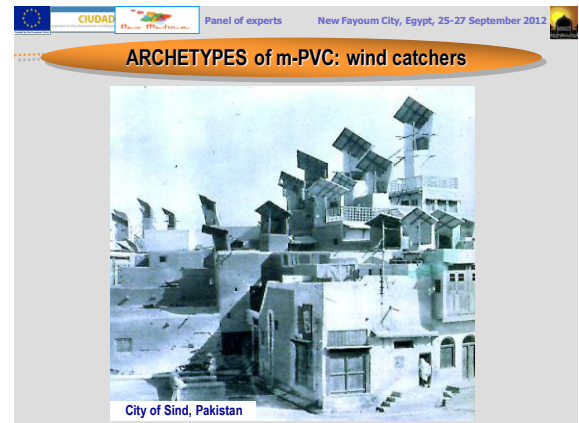
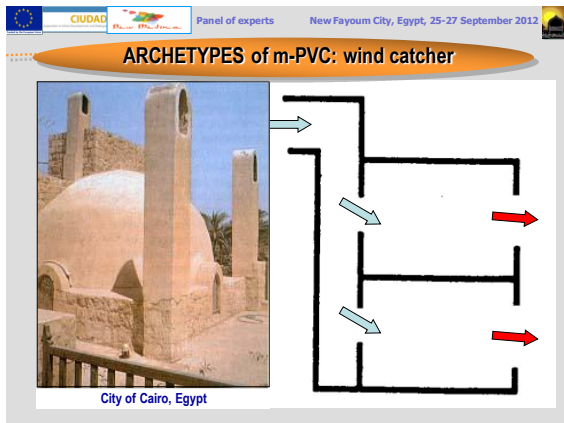
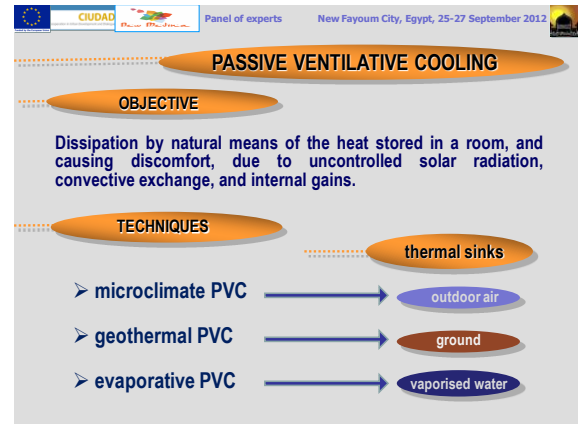
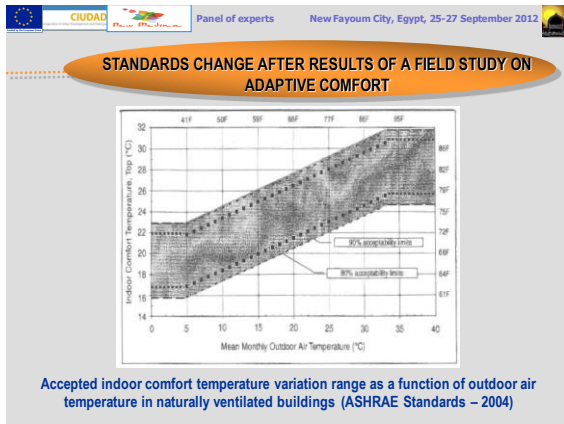
Buildings with Natural Ventilation

Indoor Comfort Temperature, Top (°C)

Outdoor Temperature Index, ET\* (°C)

Legend: Observed: Field-based adaptive model, Predicted: Lab-based PMV model

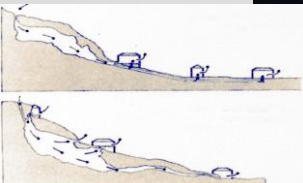

Study by a LBNB' team, Berkeley, 2003: comparison between indoor comfort conditions perceived and calculated, in sample buildings with natural ventilation



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### ARCHETYPE of g-PVC

Renaissance Palladian Villa "Trento" at Costoza (VI), Italy: longitudinal cross section

Natural underground ducts called "covoli", with extension of artificial tunnels built by Ancient Romans for a calcareous quarry.

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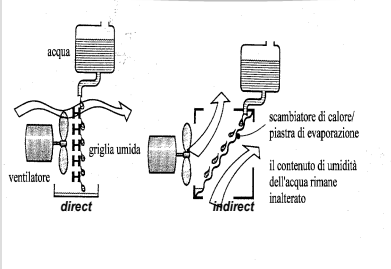
### ARCHETYPE of g-PVC




Renaissance Palladian Villa "Trento" at Costoza (VI), Italy, with natural underground ducts called "covoli"

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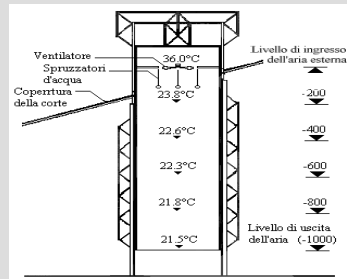
### FUNCTIONAL SCHEME of e-PVC



Room evaporative hybrid ventilative cooling system.

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### EXAMPLE of e-PVC



Temperature (°C)	Level (m)
36.0	0 (Livello di ingresso dell'aria esterna)
23.8	-200
22.6	-400
22.3	-600
21.8	-800
21.5	-1000 (Livello di uscita dell'aria)

Downdraft evaporative hybrid ventilative cooling system, Negev, Israel.

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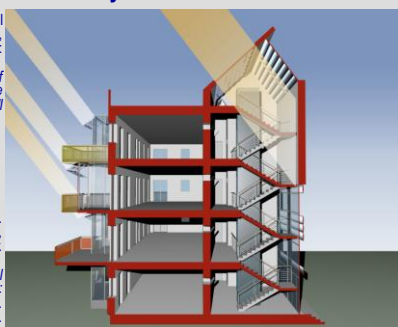
### Examples of building design with m-PVC

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### Solar-chimney-driven m-PVC

Design of a residential building, Rome, Italy:

3-D representation of solar irradiation on the chimney wall



Designer: Arch. M. Irene Cardillo, Rome, Italy:

Environmental Consultant: Prof. arch. M. Grosso.

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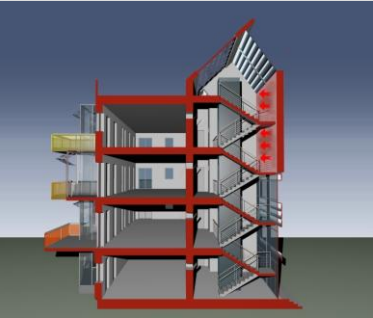
### Solar-chimney-driven m-PVC

Design of a residential building, Rome, Italy:

3-D representation of night re-irradiation from the solar chimney wall.

Designer : Arch. M. Irene Cardillo, Rome, Italy.

Environmental Consultant : Prof. arch. M. Grosso.



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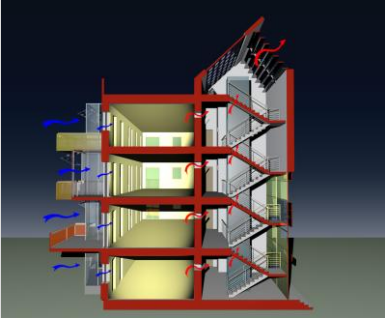
### Solar-chimney-driven m-PVC

Design of a residential building, Rome, Italy:

3-D representation of airflow during a summer night

Designer : Arch. M. Irene Cardillo, Rome, Italy.

Environmental Consultant : Prof. arch. M. Grosso



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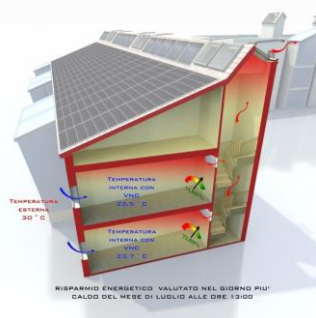
### Solar-chimney-driven m-PVC

Design of a residential-tertiary compound, Cabiato, Como, Italy:

Perspective section with representation of CNV flows and results from an energy simulation for a terrace house with stack effect in a North-facing stairways cavity

Designer: Arch. M. Irene Cardillo, Rome, Italy.

Environmental Consultant: Prof. arch. M. Grosso



TEMPERATURA INTERNA CON VMC 23.9 °C  
TEMPERATURA INTERNA SENZA VMC 22.9 °C  
RISPARMIO ENERGETICO VALUTATO NEL GIORNO PIU' CALDO DEL MESE DI LUGLIO ALLE ORE 13:00

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### Solar-chimney-driven m-PVC

Design of a residential-tertiary compound, Cabiato, Como, Italy:

Perspective section with representation of CNV flows and results from an energy simulation for a multi-apartment building with North-facing dedicated stack cavity

Designer: Arch. M. Irene Cardillo, Rome, Italy.

Environmental Consultant: Prof. arch. M. Grosso



TEMPERATURA INTERNA CON VMC 23.9 °C  
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### Solar-chimney-driven m-PVC

Design of a residential-tertiary compound, Cabiato, Como, Italy:

Perspective section with representation of CNV flows for a multi-apartment building with dedicated central stack cavity

Designer: Arch. M. Irene Cardillo, Rome, Italy.

Environmental Consultant: Prof. arch. M. Grosso



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### Solar-chimney-driven m-PVC

Design of a residential-tertiary compound, Cabiato, Como, Italy:

Perspective section with representation of CNV flows and results from an energy simulation for a multi-apartment building with stack effect in a South-facing stairways cavity

Designer: Arch. M. Irene Cardillo, Rome.

Environmental Consultant: Prof. arch. M. Grosso





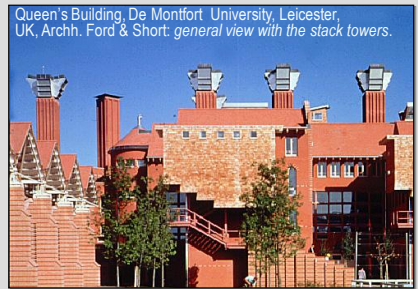
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## Examples of buildings with PVC systems

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### Stack-driven m-PVC

Queen's Building, De Montfort University, Leicester, UK, Archh. Ford & Short: general view with the stack towers.



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### Stack-driven m-PVC

Queen's Building, De Montfort University, Leicester, UK, Archh. Ford & Short: view of a stack tower top and the drawing room skylights.

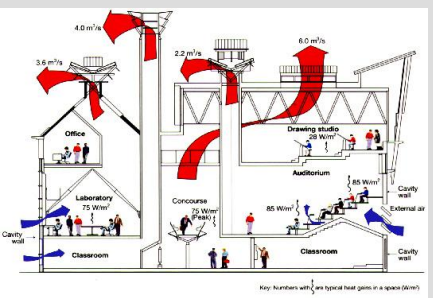


North-facing inlet vents (auditorium)

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### Stack-driven m-PVC

Queen's Building, De Montfort University, Leicester, UK, Archh. Ford & Short: cross section with a scheme of CNV flows and relevant airflow rates.



Key: Numbers with  $\frac{1}{2}$  are typical heat gains in a space (kW/m²)



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### Junior high school building "L. Orsini", Imola, Italy:




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### Junior high school building "L. Orsini", Imola, Italy: Night cooling of thermal mass

Atrium glazed roof with the exhaust air stack vented clerestory

